517-CD-001-004

EOSDIS Core System Project

Failure Modes and Effects Analyses (FMEA) and Critical Items List (CIL) for the ECS Project

January 1996

Hughes Applied Information Systems
Upper Marlboro, Maryland

Failure Modes and Effects Analyses (FMEA) and Critical Items List (CIL) for the ECS Project

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SUBMITTED BY

Cal Moore /s/ 1/26/96

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Hughes Information Technology Systems
Upper Marlboro, Maryland

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Preface

This document is a contract deliverable with an approval code 2. As such, it does not require formal Government approval, however, the Government reserves the right to request changes within 45 days of the initial submittal. Once approved, contractor changes to this document are handled in accordance with Class I and Class II change control requirements described in the EOS Configuration Management Plan, and changes to this document shall be made by document change notice (DCN) or by complete revision.

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1. Introduction

1.1 Identification

This document is submitted as required by CDRL item 090, DID 517/PA2, whose requirements are specified in this document as a deliverable under the Earth Observing System Data and Information System (EOSDIS) Core System (ECS) contract (NAS5-60000).

1.2 Scope

This document incorporates the Government's comments to the Failure Modes and Effects Analysis/Critical Items List (FMEA/CIL) deliverable which was submitted at the (FOS) Critical Design Review (CDR) time frame. This submittal addresses all GSFC Code 300 findings stated in the Data Item Description (DID) approval letter received by HAIS on November 8, 1995.

This version of the analysis is a final submittal as required by CDRL item 090, DID 517/PA2 which provides updated information to reflect the FOS Release A/B hardware configuration at the Critical Design Review (CDR) time frame. The analysis approach to be used for this FMEA is a hardware approach by which each potential hardware failure mode of the Critical Command and Control (or Critical Real-Time) systems of the FOS and the related network equipment that supports the Real-Time functions, is analyzed to determine the effects thereof on the overall ECS system and to classify each potential failure mode according to its severity.

The analysis does not quantify the probability for failure occurrence; but rather a qualitative assessment of the failure effect is gained by assigning the failure mode to a severity category.

This document reflects the August 23, 1995 Technical Baseline maintained by the contractor configuration control board in accordance with the ECS Technical Direction No.11, dated December 6, 1994.

1.3 Purpose and Objectives

The purpose of the FMEA is to identify potential catastrophic and critical failures of the FOS critical real-time functions so that susceptibility to the failures and their effects can be reduced or eliminated from the ECS system. The analysis was directed to reveal any single point failures in the FOS components that provide critical real-time functions so that such failures can be completely eliminated. In the event that potential critical failures cannot be eliminated, mitigation plans will be identified to ensure that the effect of a failure on the overall ECS system is minimal. Since the individual failure modes are listed and evaluated in an orderly fashion, the FMEA also serves to verify the FOS Real Time design integrity, identify undesirable failure modes and document reliability risks. FMEA results not only provide design guidance, but can be used advantageously during maintenance planning analysis, logistics support analysis, hazard analysis, and fault recovery management design.

1.4 Document Status and Schedule

This submittal of DID 517/PA2 meets the milestone specified in the Contract Data Requirements List (CDRL) of NASA contract NAS5-60000. This is the final submittal which incorporates all GSFC Code 300 findings and comments stated in the Data Item Description (DID) approval letter received by HAIS on November 8, 1995.

1.5 Document Organization

The document is organized into six (6) sections and one Appendix:

Section 1	Introduction, contains the identification, scope, purpose and objectives, status and schedule, and document organization.
Section 2	Related Documents, provides a bibliography of parent, applicable and information documents for the FMEA and CIL.
Section 3	Flight Operations Segment (FOS) Description, provides a brief FOS Hardware Architecture and FOS Critical Command and Control System descriptions
Section 4	FOS FMEA Methodology, describes the specific requirements, ground rules and assumptions for the FMEA, the detailed FMEA Data and Worksheets as well as the definitions of Failure Criticality Classifications.
Section 5	FOS FMEA Results, provides the summary results of the FOS Real Time FMEA with their associated design recommendations and mitigation plans.
Section 6	FOS Critical Items List (CIL), describes the criteria for critical items, their associated mitigation plans, and the justification for retention of the items on the list.
Appendix A	FMEA Detailed Worksheets, provides a complete set of the detailed FMEAworksheets as a result of the analysis.

2. Related Documentation

2.1 Parent Documents

The parent document is the document from which this FMEA/CIL document scope and content are derived.

194-207-SE1-001	Systems Design Specification for the ECS Project
420-05-03	Goddard Space Flight Center, Earth Observing System (EOS) Performance Assurance Requirements for the EOSDIS Core System (ECS)
423-41-01	Goddard Space Flight Center, EOSDIS Core System (ECS) Statement of Work
423-41-02	Goddard Space Flight Center, Functional and Performance Requirements Specification for the Earth Observing System Data and Information System (EOSDIS) Core System
423-41-03	Goddard Space Flight Center, EOSDIS Core System (ECS) Contract Data Requirements Document

2.2 Applicable Documents

The following documents are referenced within this FMEA/CIL document, or are directly applicable, or contain policies or other directive matters that are binding upon the content of this volume.

194-501-PA1-001	Performance Assurance Implementation Plan (PAIP) for the ECS Project
194-502-PA1-001	Contractor's Practices & Procedures Referenced in the PAIP for the ECS Project
304-CD-001-002	Flight Operations Segment (FOS) Requirements Specification for the ECS Project, Volume 1: General Requirements
304-CD-004-002	Flight Operations Segment (FOS) Requirements Specification for the ECS Project, Volume 2: Mission Specific
GSFC S-302-89-01	Procedures for Performing a Failure Mode and Effects Analysis (FMEA)

2.3 Information Documents

The following documents, although not referenced herein and/or not directly applicable, do amplify or clarify the information presented in this document. These documents are not binding on the content of the FMEA/CIL document.

305-CD-001-002 311-CD-001-002	Flight Operations Segment (FOS) Design Specification and FOS Database Design and Database Schema Specifications for the ECS Project
MIL-STD-785	Military Standard: Reliability Program For Systems and Equipment Development and Production, Task 204
MIL-STD-1629A	Military Standard No. 1629A: Procedures For Performing A Failure Mode And Effects Analysis (FMEA), Task 101
FMD-91/RAC	Failure Mode/Mechanism Distributions 1991, Reliability Analysis Center

3. Flight Operations Segment (FOS) Overview

3.1 FOS Hardware Architecture Description

The FOS physical architecture, in keeping with the overall ECS design approach, consists entirely of COTS products. The architecture is "open systems based" so that it remains vendor independent. By providing redundant systems and network segments, this design ensures that all single points of failure in the Flight Operations area are eliminated.

FOS will evolve during the EOS mission lifetime to accommodate changes in both the mission and mission operations center technology. To facilitate this evolution, the FOS system will use commercial protocols and standards, and will be developed with COTS where cost effective. The FOS will use automation where it increases productivity, reduces operations risk, and reduces life cycle costs. A modular design will enable technology advancements to be inserted, while improving system maintainability.

The FOS consists of two elements -- the EOS Operations Center (EOC) and the Instrument Support Toolkit (IST).

The EOC will be located at Goddard Space Flight Center. It is responsible for the high-level monitoring and control of all instruments on-board the U.S. EOS spacecraft. It will maintain spacecraft and instrument health and safety, monitor spacecraft performance, perform spacecraft engineering analysis, perform high-level monitoring of the mission performance of the instruments, and provide periodic reports to document the operations of the spacecraft and instruments.

The IST is a software toolkit that will be delivered to the Principal Investigator/Team Leader (PI/TL) sites for U.S. EOS instruments. An IST provides access to the EOC functions for those individuals who are not physically located at the EOC. It enables PIs and TLs to participate in the planning, scheduling, commanding, monitoring, and analysis of their instruments.

The FOS computers have been designed to distribute the disparate operational tasks (i.e., scheduling, real-time, and analysis) between the User Stations and the servers within the FOS network to balance the performance load. Communications interface services are provided by the CSMS Internetworking Subsystem (ISS). This includes the EOC Local Area Networks (LANs) and the associated network interfaces to other ECS facilities (such as the SMC and the GSFC DAAC), as well as network interfaces to external systems (such as the interface to EBnet and NSI). NSI connects the EOC to the ISTs. The network connectivity to EDOS, FDF, and NCC is through EBnet. SCDO also provides the Local System Manager (LSM), which provides network and system management services, and the Multicast Server, which allows ISTs to receive multicast traffic from the EOC.

Figure 3-1 is a diagram of the FOS Physical Architecture with its major hardware components. Each of the components has been grouped into hardware configuration items (HWCI). A detailed description of the FOS critical real-time hardware component is provided in Section3.2.

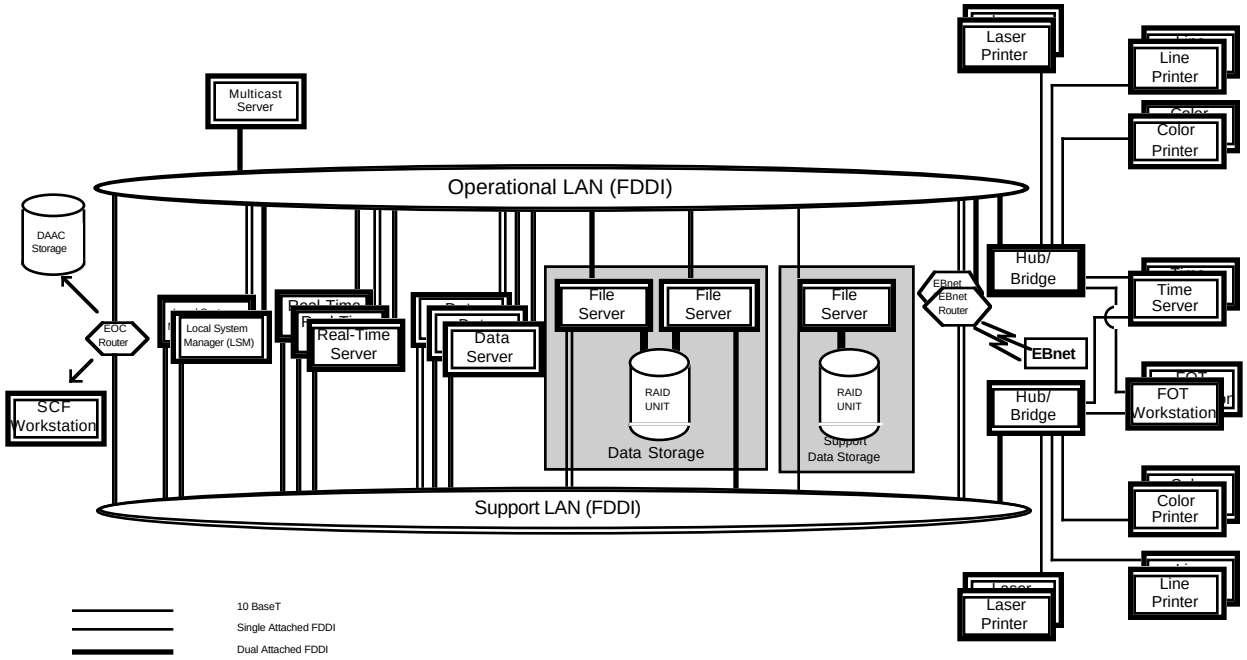

Figure 3-1. FOS Physical Architecture

3.2 FOS Critical Command and Control Systems

FOS Critical Command and Control Systems are systems that provide critical real-time functions to support the following: launch, early orbit checkout, orbit adjustment, anomaly, investigation, recovery from safe mode, routine real-time commanding and associated monitoring for spacecraft and instrument health and safety. This includes the execution and control of the ground script; the uplink of spacecraft loads, instrument loads and real-time commands; command verification; ingest and monitoring of the real-time housekeeping telemetry and replay telemetry; and the capture and recording of real-time deviations to the planned ground script to ensure that the as-flown ground script is accurate.

For Release A/B, the FOS Critical Command and Control Systems that perform critical real-time functions consist of redundant groups of Real-Time Servers, Data Servers (for Events archiving function only), User Stations, RAID (Redundant Array of Independent Disks) storage devices, Time Systems, and network equipment (LAN concentrators and LAN hub/bridge assemblies). The following sections are detailed descriptions of each group of hardware.

3.2.1 Real-Time Server

The Real-Time Server hosts the functions required to support the real-time contacts. In particular, it provides a single location in the system where real-time telemetry monitoring is always performed independent of the users. In addition, it is the location where commands and command loads that are uplinked to the spacecraft via EDOS are validated, built, transmitted, and verified.

The DEC OSF/1 version 3.2 operating system (IEEE 1003.1 compliant) will reside on each of the Alpha 1000 4/233 servers. POSIX compliant real-time extensions, IEEE 1003.4, are built into the kernel, and utilized by the applications. To provide 100% failover/redundancy, 3 servers are provided, each identically configured. Although multiple spacecraft can be supported from a single server, to further distribute the workload, additional servers can be added.

The Real-Time Servers consist of two operational machines, plus a third for support (i.e., testing, training, software development). Each operational server will be capable of supporting all of the users should the other fail. The third server can become operational in the event of either of the others failing. Physically, nothing will change to move the third server into production. Each system will have a dual network connection (to both operational and support LANs) eliminating the network connection as a single point of failure. The Server will be configured through software so that it is active on either the operational or support LAN, but not both, at any one time.

The server will be configured with 256MB of memory. Memory is expandable to 512MB should the requirement arise. Four gigabytes of disk space will reside locally on the server. The operating system, swap space, and software will reside on these disks. Data files will reside on remote storage, that is made available across the network. The network is designed to enable reliable and quick access to the database. A CD-ROM and digital tape drive (DAT) will reside locally on each server, eliminating unnecessary network traffic. This allows for simultaneous software upgrades/installations, as well as local backups as needed without adding network traffic. The system console (monitor and keyboard) will be located in the equipment room. The purpose of the console is for system administration and troubleshooting the machine.

3.2.2 Data Server

The Data Server will be primarily used by the DMS (Data Management Subsystem). The Data Server will receive back orbit telemetry data from EDOS. The DMS merges this data with the real-time telemetry maintained at the local archive to create a seamless archive, upon which statistics on the housekeeping telemetry are generated.

The Data Server supports the servicing of telemetry, event and data requests. These requests can be received from any EOC User Station or IST. The DMS's function to archive events will reside at the Data Server. Each incoming event will be stored in the archive. A copy of the events archive data is sent to the SDPS for long term storage.

The DEC OSF/1 version 3.2 operating system (IEEE 1003.1 compliant) will reside on each of the Alpha 1000 4/233 servers. Three identical data servers are provided, two operational machines, and a third for support. To provide 100% redundancy, each server is identically configured.

The Alpha 1000 4/233 is rated at 165.3, thus accommodating the current processing requirements, as well as providing for growth. Much of the processing will be distributed to the User Stations. Server processes will include: communications daemons, database daemons, and server associated database activities.

Each operational Data Server will be capable of supporting all users should the other fail. The third server can become operational in the event of either of the others failing. Physically, nothing will change to move the third server into production. The server can be switched from the support to operational LAN via the software. The Server will be configured through software so that it is active on either the operational or support LAN, but not both, at any one time. Each system will have a dual network connection (to both operational and support LANs) eliminating the network connection as a single point of failure.

Because of the memory demands of current commercial databases, the Data Server will be configured with 256MB of memory. The Sybase server software requires 8-10MB of memory plus a minimum of 48kb of server memory per user. With 50 users simultaneously connected to Sybase, an additional 2.3MB of memory would be needed, bringing the total to 12.3MB. Even with the server processes mentioned above, there is room for performance tuning of memory. The 256MB of memory will reduce the processes swapped to disk during operation.

Six gigabytes of disk space will reside locally on the server. The operating system, swap space, and software will reside on two of these disks. Swap space will be distributed across 2 disks for faster swapping. The operating system and swap space require a total of 750MB to 1GB of disk space. Application and development software should require no more than 1GB of storage. Data files can reside locally, or on remote storage, that is made available across the network.

A CD-ROM and digital tape drive (DAT) will reside on each of the machines. This will allow for software upgrades and installations, as well as local backups as needed without adding network traffic. Each system will have a dual connection to the network. The system console (monitor and keyboard) will be located in the equipment room. The purpose of the console is for administration and troubleshooting the machine.

3.2.3 User Stations

FOT user workstations are provided in the Flight Operations area. A majority of the processing initiated by a user will be performed on the User Station. Due to the distributed architecture, a mid-range workstation is provided for the users. Like the servers, a IEEE 1003.1 POSIX compliant (UNIX) operating system will be supplied. Each User Station will be configured identically. Initially, 36 User Stations will be deployed.

Because data is available via network attached data storage unit, local storage is minimized. Portions of the application software will be installed at the server level, so only operating system, client, and client application software need to reside locally. Two gigabytes of disk space will be available locally for this software, swap space, and temporary local storage. The User Station will be upgradeable to a minimum of 4 gigabytes.

The User Stations will consist of Sun SPARCstation 20 Model 71 workstations. The User Station will be configured with 64MB of memory. Because of the overhead associated with the operating system and the various network software, this is the recommended minimum. Previous experience, benchmarking, and prototyping has demonstrated noticeable performance degradation with 32MB or less memory. The User Station memory is upgradeable to 512MB.

To allow the users to display and manage multiple windows, a 21" color monitor, resolution 1280x1024, with mouse and keyboard will be configured with each User Station. In the Mission Operations Room each of the 4 workstations will be configured with two 21" color monitors.

3.2.4 Data Storage

The data storage for all servers and user workstations is centrally located on a fault-tolerant Data Storage Unit. The unit consists of 2 front-end file servers connected to a fault-tolerant RAID unit with redundant controllers, power supplies and fans. The unit will support RAID levels 3 and 5, and will have no single point of failure.

Initially, the data storage unit will be configured with 60.2 gigabytes of raw disk space. This will leave 60% of the disk space free, based on expected storage requirements of 20GB for Release B. Because of redundancy, a total of 14 - 4.3GB drives are configured to provide 49.9GB of usable disk. RAID levels 3 and 5 stripe data across disks, with a parity code interleaved with the data. Both use the same overhead for redundancy. Because a majority of the I/O requests are for large reads and writes (telemetry files), RAID level 5 will be implemented. RAID-5 uses larger chunks of data, providing faster read/write access for larger files. RAID-3 uses bit-sized chunks, which is more efficient for short I/O bursts.

The two FDDI controllers (for redundancy) will each be dual attached to the network. The disk drives will be hot-swappable. All components will be rack mountable, redundant, and either hot or warm swappable.

All servers and workstations have direct access to the data. The front-end processor(s) to the storage unit will maintain and export the file system to all servers and workstations in the FOS room.

3.2.5 Time Systems

Currently, two timing servers will be installed in the EOC. This synchronizes the time of the various Real-Time and Data servers with the NASA-36 bit time interface. Both will be rack mounted in the equipment room. A single point of failure has been eliminated by providing 2 Government Furnished Equipment (GFE) NASA-36 sources. This time source, via switching, routed through a GFE Synchronized Time Code Generator (1 per source for failover), to the time server. The time server will provide time via the Network Time Protocol (NTP) to the Real-Time and Data servers. Should both NASA-36 time sources be interrupted, a Sync Gen's will continue as the time source until the NASA-36 source is restored. This equipment will be rack mounted in the equipment room. Distributed Computing Environment (DCE) timing services will be used for distributing the time to the User Stations and ISTs.

The time source will also be sent to GFE Up-Counters and Down-Counters (located in the equipment room). Displays will be mounted in the Mission Operations Room, and the Launch and Test room. The timing solution will be expandable so that additional displays may be added throughout the EOC.

3.2.6 EOC Network Equipment

Redundant concentrators and hubs/bridges will be used as part of the FOS network architecture. The external interface router to EBnet (provided by EBnet) is also fully redundant.

The EOC LANs will contain three types of COTS hardware: FDDI (Fiber Distributed Data Interface) concentrators, FDDI-to-Ethernet hubs, and FDDI routers. The FDDI rings within the EOC will be implemented via FDDI concentrators, and the FDDI router will be used to connect the EOC with the ISTs and the GSFC DAAC. The FDDI-to-Ethernet hubs will be used to connect the EOC workstations to the FDDI backbone. The network can be expanded to support 100 workstations.

The hub architecture is both scalable and evolvable. As the number of network devices increases, cards can be added to the hub, and, if needed, several hub cabinets be "chained" together. Dual-attached hosts will be dual-homed to two separate FDDI concentrators to provide an additional level of redundancy in the event of a hub failure. As illustrated in Figure 3-1, the use of redundant hubs, each connected to redundant FOS devices, provides complete redundancy so that even a full hub failure will not remove critical real-time functionality from FOS.

3.3 FOS External Interfaces

The diagram in Figure 3-2, FOS External Interface Context Diagram, shows the relationship between the FOS and its external interfaces. Table 3-1 summarizes the FOS external interfaces, and includes the nominal frequency for each interface item in addition to providing the source and destination of the interface and a description of the data. There are several notes pertaining to the FOS external interfaces:

- The FOS interface with the International Partner Instrument Control Center (IP-ICC) could be applied to any ICC that is external to the FOS, even one within the U.S.
- The FOS interface to the Science Computing Facility (SCF). The SCF is the facility that provides the hardware where the IST software toolkit resides. However, while every EOS instrument has an IST software toolkit, not every EOS instrument has an SCF (e.g., MOPITT instrument on the AM-1 spacecraft) .
- CSMS MSS Interface: The CSMS Management Subsystem (MSS) sends the Long-Term Instrument Plans and the Long-Term Science Plans to the FOS. These sets of plans are produced/updated by the Investigator Working Group (IWG) every six months and cover a period of up to approximately five years. The FOS sends management and operational status information to the CSMS MSS. The MSS provides the FOS with operational status messages.

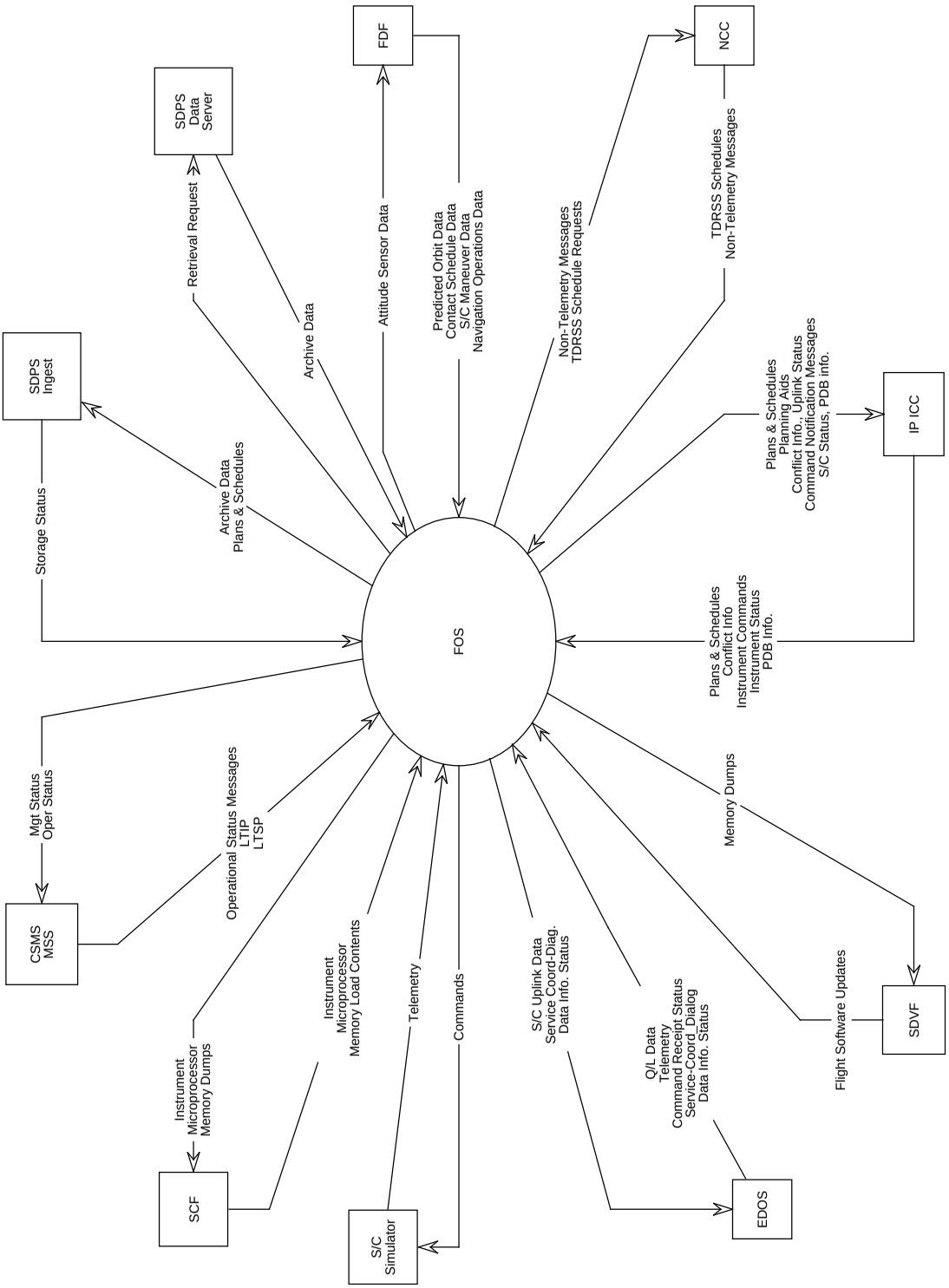

Figure 3-2 FOS External Interface Context Diagram

- SDPS Ingest Interface: SDPS Ingest provides long-term archiving services for the FOS. The data sent to SDPS Ingest includes the spacecraft and instrument housekeeping telemetry, engineering telemetry, event history data. (Note: this data can be retrieved from the SDPS at a later time. The retrieval operation is done via the SDPS Data Server interface.)

Table 3-1. Flight Operations Segment External Interfaces (1 of 2)

Source	Destination	Data Description	Frequency
CSMS MSS	FOS	LTIP	every 6 months
CSMS MSS	FOS	LTSP	every 6 months
CSMS MSS	FOS	Operational status messages	each TDRSS contact
FOS	CSMS MSS	Management status	as required
FOS	CSMS MSS	Operational status	as required
FOS	SDPS Ingest	Archive data	daily for long-term storage
FOS	SDPS Ingest	Plans and Schedules	daily
SDPS Ingest	FOS	Storage status	for each long-term storage request
FOS	SDPS Data Server	Retrieval request for FOS data in long-term archive	as requested primarily for analysis
SDPS Data Server	FOS	Archive data	as requested primarily for analysis
FDF	FOS	Predicted orbit data	daily/weekly
FDF	FOS	Contact schedule data	daily/weekly
FDF	FOS	Spacecraft maneuver data	nominally every 45 days
FDF	FOS	Navigation operations data	daily
FOS	FDF	Attitude sensor data	each spacecraft contact
NCC	FOS	TDRSS schedules	weekly/ daily updates
NCC	FOS	Ground-telemetry messages	each TDRSS contact
FOS	NCC	TDRSS schedule requests	weekly/ daily updates
FOS	NCC	Ground-telemetry messages	each TDRSS contact
IP-ICC	FOS	Plans and schedules	daily
IP-ICC	FOS	Conflict info	nominally daily
IP-ICC	FOS	Instrument commands	infrequent; based on mission requirement
IP-ICC	FOS	Instrument status	weekly
IP-ICC	FOS	Data base information	nominally every 3 months
FOS	IP-ICC	Plans and schedules	daily

Table 3-1. Flight Operations Segment External Interfaces (2 of 2)

Source	Destination	Data Description	Frequency
FOS	IP-ICC	Planning aids	daily/weekly
FOS	IP-ICC	Conflict info	as applicable
FOS	IP-ICC	Uplink status	each IP-ICC command sequence
FOS	IP-ICC	Command notification messages	each unplanned IP-ICC command issued from EOC
FOS	IP-ICC	Spacecraft status	weekly
FOS	IP-ICC	Data base information	nominally every 3 months
SDVF	FOS	Flight software updates	infrequent 4/year
FOS	SDVF	Memory dumps	as requested 4/year
EDOS	FOS	Telemetry	each spacecraft contact
EDOS	FOS	Command receipt status	each command sequence
EDOS	FOS	Service coordination dialogue	prior to spacecraft contact
EDOS	FOS	Data information status (CODAs)	periodically during each spacecraft contact
FOS	EDOS	Spacecraft uplink data	each command sequence
FOS	EDOS	Service coordination dialogue	each spacecraft contact
FOS	EDOS	Data information status	each spacecraft contact
Spacecraft Simulator	FOS	Telemetry	as required; nominally infrequent
FOS	Spacecraft Simulator	Command	as required; nominally infrequent
SCF	FOS	Instrument Microprocessor Memory Load	as required; nominally infrequent
FOS	SCF	Instrument Microprocessor Memory Dump	as required; nominally infrequent

- Additionally, the FOS sends mission plans and schedules to the SDPS Ingest.
- SDPS Data Server Interface**:** The SDPS Data Server processes requests for FOS data that has been previously stored in the long-term archive.

- FDF Interface: The Flight Dynamics Facility (FDF) sends predicted orbit data to the FOS, which includes predicted ground track data for scheduling purposes. The FDF also sends contact scheduling data including User Antenna View (UAV) data and Predicted Site Acquisition Tables (PSAT's) to the FOS. The FDF develops plans for spacecraft maneuvers in conjunction with the FOS. The FDF sends the spacecraft maneuver parameters to the FOS. The FOS schedules and implement these plans. The FDF also sends FDF parameters needed for spacecraft on-board table generation to the FOS. FDF parameters consist of navigational operational parameters and spacecraft maneuver parameters.
- The FOS will provide attitude sensor data to the FDF for analysis. This data is a subset of the spacecraft housekeeping telemetry nominally captured by the FOS during a real-time contact. In addition, back orbit telemetry subsets may also be sent to the FDF from the FOS.
- NCC Interface: The FOS submits TDRSS schedule requests and non-telemetry messages (e.g., link reconfiguration requests) to the Network Control Center (NCC) . In response, the NCC sends TDRSS schedules notifying the FOS of the status of its request and non-telemetry messages (e.g., TDRSS link status messages, performance data). In the event TDRSS is unavailable, the FOS will also interface with the NCC to schedule ground station contacts with the contingency network (i.e., Space Network, Ground Networks or Wallops Orbital Tracking Station).
- IP-ICC Interface: International Partners (IPs) may provide their own Instrument Control Center (ICC) for their instrument on-board an EOS spacecraft. For example, Japan will provide an IP-ICC for its ASTER instrument on-board the AM-1 spacecraft. The IP-ICC provides instrument plans and schedules to the FOS, and coordinates scheduling conflicts with the FOS when they arise. The FOS sends planning aids, integrated mission plans and schedules to the IP-ICC for analysis to refine instrument scheduling, and also receives scheduling conflict information from the FOS.
- An IP-ICC can send instrument commands to the spacecraft via the FOS. The FOS will validate the command sent from an IP-ICC and build the command bit pattern. It will then send it to the spacecraft via the EOS Data and Operations System (EDOS) interface. FOS reports on the uplink status to the IP-ICC. In addition, the FOS can send commands to the spacecraft on behalf of the instrument (e.g., to safe the instrument). The FOS notifies the IP-ICC with a command notification message in this situation.
- An IP-ICC can send instrument data base update requests to the FOS. After the data base update request has been approved, or whenever a new project data base has been established in the FOS, the updated project data base will be sent to the IP-ICC.
- Periodically, the FOS sends mission status information to the IP-ICC, and the IP-ICC sends instrument status to the FOS.
- SDVF Interface: The Software Development and Validation Facility (SDVF) sends flight software loads to the FOS. These loads are scheduled by the FOS for subsequent uplink to the spacecraft. The FOS sends memory dumps to the SDVF.

- EDOS Interface: The FOS sends spacecraft uplink data, including spacecraft and instrument commands and command loads, to the spacecraft via the EDOS interface. EDOS, in turn, provides the FOS with command receipt status. Service coordination dialogue messages and data interface status messages are also sent between the FOS and EDOS.
- EDOS sends spacecraft and instrument housekeeping telemetry in real-time from the spacecraft to FOS. This data will be used by the Flight Operations Team (FOT) to monitor the health and safety of the spacecraft and instruments during real-time contacts, and to perform command verification.
- EDOS also sends back-orbit housekeeping telemetry from the spacecraft to FOS. This data will be sent via the rate-buffered service that EDOS provides after a contact has been completed. The FOS will maintain an archive of merged telemetry to be used for trending, anomaly investigation, reports, and performance analysis.
- Spacecraft Simulator Interface: The FOS sends spacecraft and instrument commands to the Spacecraft Simulator. The Spacecraft Simulator sends simulated spacecraft telemetry to the FOS. This interface is provided for the purpose of flight operations training and development, and validation of operational procedures.
- SCF Interface: Microprocessor memory loads for instruments can be submitted to the FOS from the SCF. These microprocessor memory loads are scheduled by the FOS for subsequent uplink to the spacecraft. The FOS sends microprocessor memory dumps to the SCF. The SCF also has a general interface with the FOS to import and export other data (e.g., telemetry data files).

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4. FOS FMEA Methodology

4.1 FMEA Requirements

4.1.1 Key Requirements

The followings are key requirements for the FOS FMEA in accordance with paragraph 5.3.4 of the EOSDIS CORE System (ECS) Performance Assurance Requirements (PAR):

a/ Analysis of redundant equipment must address cross-strapping to ensure that no single failure will adversely affect the performance of the redundant capability.

b/ No single failure will prevent the successful removal of power from a failed flight instrument.

c/ No single point of failure in the components that provide critical real-time functions.

4.1.2 Hardware Level Of Analysis

The FMEA is a bottom-up methodology and is initiated by defining the hardware lowest level of interest. The various failure modes that can occur for each item at that level are tabulated. The corresponding failure effect, in turn, is interpreted as a failure mode at the next higher functional level. Successive iterations result ultimately in identification of the failure effects up to the FOS Critical REal-Time functions.

During the FOS critical design phase, the FMEA was conducted at the equipment level and the line replaceable unit (LRU) level wherever applicable. The equipment was based on specific hardware models that are proposed during the CDR time frame.

4.2 Failure Criticality Classifications

The FOS FMEA failure mode criticality classifications are defined and assigned with number in accordance with paragraph 5.3.4 of the PAR as follows:

Criticality 1: A single failure that could result in loss of human life, serious injury personnel, loss of mission, or loss of spacecraft and instrument or a major portion of the ECS facility.

Criticality 2: A single failure that could result in a loss of a primary mission objective (as defined by the ECS project) or significant damage to the spacecraft and instrument.

Criticality 3: A single failure that could result in a loss of a secondary mission objective (as defined by the ECS project), significant damage to an instrument or degradation of science products (as defined by the ECS project), or loss of data identified as critical by the Project.

Criticality 4: Loss of system capability that does not significantly impact the science mission.

4.3 Ground Rules and Assumptions

The FOS FMEA was conducted based on the following ground rules and assumptions:

- Only the Critical Command and Control systems that provide critical real-time functions of the FOS were analyzed.
- The mission phase under analysis was the real-time phase. This phase focuses on the functions that are performed during the pre-contact, contact, and post-contact phases. This includes the execution and control of the ground script; the uplink of spacecraft loads, instrument loads and real-time commands; command verification; ingest and monitoring of the real-time housekeeping telemetry and replay telemetry; and the capture and recording of real-time deviations to the planned ground script to ensure that the as-flown ground script is accurate. The functionality for the real-time phase is partitioned between six (6) subsystems of the FOS: the Command, Telemetry, Resource Management, Real-Time Contact Management, User Interface, and Data Management subsystems.
- Only one failure mode exists at a time.
- Failures modes that occur within an equipment and/or LRU, be it electrical or mechanical, are manifested at the interface by one of the following failure conditions as defined per the GSFC S-302-89-01, Procedures For Performing a FMEA:
  - Premature operation,
  - Failure to operate at a prescribed time,
  - Failure to cease operations when required,
  - Failure during operation.
- Failures due to human error in system setup (e.g., procedural or induced errors) were not considered. Such items (that constitute a safety concern) were considered in the hazard analysis, DID 513/PA2.
- Failure of redundant equipment will be notified by the system software diagnostic. All failed redundant equipment are on-line repairable and will be immediately repaired or replaced at the site by maintenance personnel.
- All inputs are present and at nominal values.
- Connector failures are limited to disconnect.

4.4 FOS Critical Real-Time Functional and Reliability Block Diagrams

The FMEA was conducted based on the FOS physical architecture or functional block diagram shown in Figure 3-1. The functional block diagram was then converted into a reliability block diagram, as shown in Figure 4-2, which is a diagram showing by concise visual shorthand the various series/parallel block combinations (paths) that result in the function success. Failure mode criticality classifications were determined and assigned to the appropriate item failure mode based on the Reliability Block diagram, the FOS Physical Architecture diagram, and the FOS External Interfaces diagram.

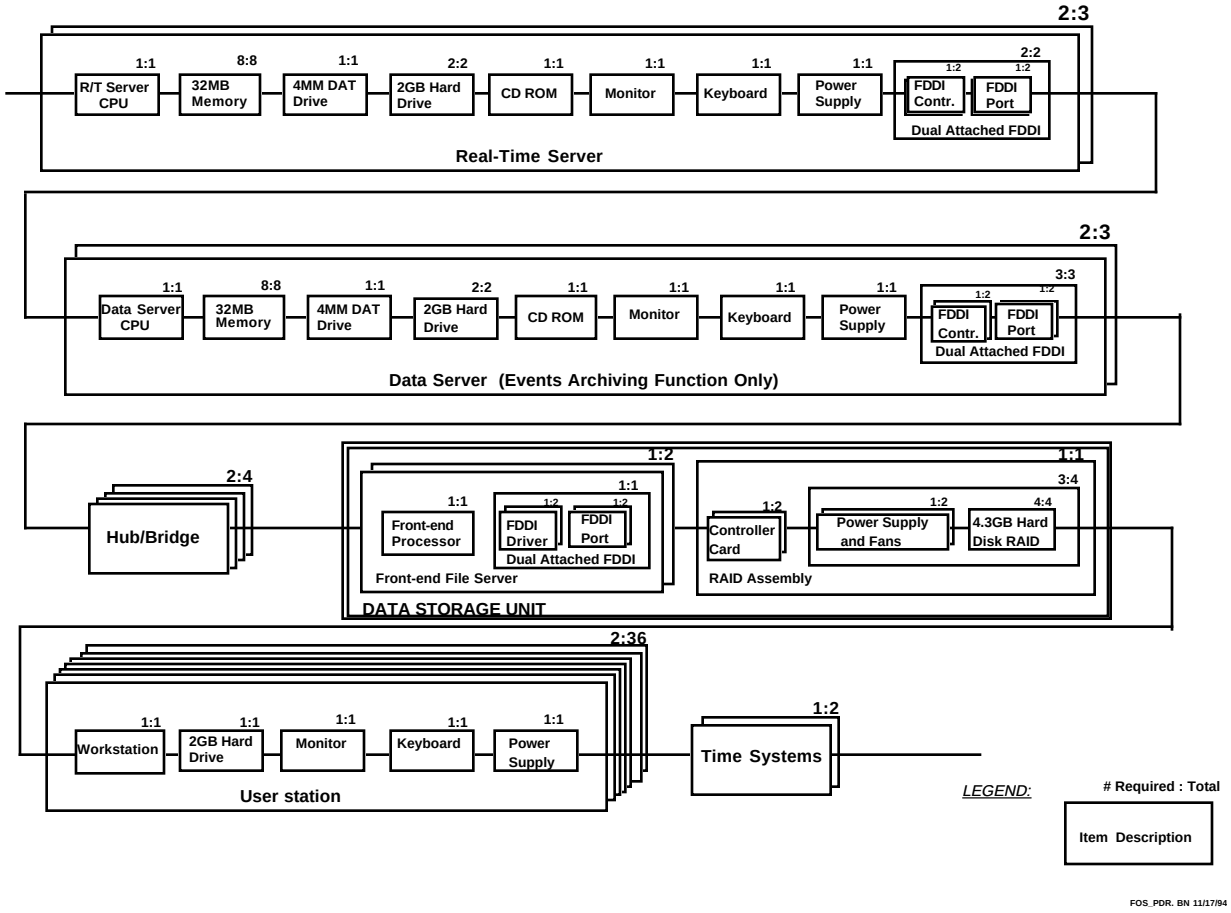

Figure 4-1. FOS Critical Real-Time Functions Reliability

4.5 FMEA Data and Worksheets

Figure 4-3, FOS FMEA worksheet, represents a sample worksheet form in which all detailed data required to conduct a FMEA are tabulated. Appendix A provides a complete set of worksheets of the FOS Critical Command and Control systems. The following is the minimum information that will be entered onto the worksheet.

- ID Number - Unique identifier for each failure mode evaluated. Enter in numerical order.
- Identification of Item- Unique equipment or equipment's LRU identifier with a brief description.
- Failure Mode/Failure Cause - Identify the specific failure mode after considering the four basic failure conditions in section 4.3 above. For each applicable hardware failure mode, list the major cause(s), e.g. separated connector, capacitor short/open, resistor short to voltage, etc.
- Failure Effects - List failure effect for each of the hardware levels being considered. List in column by a, b, c, as below:

  a. Local Level: Enter a brief description of the failure effect at the subsystem level.

  b. Next Higher Level: Enter the failure effect at the next assembly level above the subsystem.

  c. System or Mission Level: Enter the effect of the failure mode on the mission. If the failure has no effect enter None.
- Criticality Classification - Assign a criticality classification number as defined in section 4.2 above.
- Remarks - Enter any pertinent information, references or comments. Specifically enter:

  a- How the failure would be detected in the data.

  b- Redundant or work around features in the design

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System _____ Date_____

Segment_____ Prepared By_____

Element/Function_____ Approved By_____

Mission Phase_____

ID Number	Identification of Item	a. Failure Mode b. Failure Cause	**Failure Effects** a. Local or Subsystem b. Next Higher Level - System c. End Effect - Mission	Criticality Classification	**Remarks** a. Failure Detection Method b. Compensating Features/Action c. Other

Figure 4-2. FOS FMEA Worksheet

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5. FOS FMEA Results

5.1 Summary of the FOS Critical Command and Control Systems FMEA Results

Based on results of the FMEA worksheets, there are a total of 35 unique LRUs analyzed in the FOS Critical Real-Time functions at the CDR time frame. Of these 35 LRUs, 123 failure modes are identified and all are Criticality 4 classifications. This means that all identified failures of the FOS Critical Real-Time or its constituents will not impact the science mission due to the FOS robust design with its extensive redundant hardware architecture. The analysis also reveals no single point of failure in the Critical Real-Time functions that will adversely affect the cross-strapping capability of redundant equipment or will prevent the successful removal of power from a failed flight instrument.

5.2 FOS Design Recommendations and Mitigation Plans

There are no design recommendations or mitigation plans suggested at this time. In the event that there is a design change within the FOS, the analysis will be updated to reflect any change that may occur during the course of the design. If any Criticality classification other than Criticality 4 are discovered, design recommendations and mitigation plans will be provided.

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6. FOS Critical Items List (CIL)

6.1 Critical Items List (CIL) Requirements

As required per paragraph 5.3.4 of the Performance Assurance Requirement (PAR) of the ECS, GSFC 420-5-03, a Critical Items List (CIL) must be provided in conjunction with the FMEA to itemize all potential catastrophic or critical failure items that meet the criteria in the following Section 6.2. The CIL, as shown in Figure 6-1, provides a listing of Equipment/LRU part numbers, reference designator (if appropriate), LRU nomenclature, failure mode ID number (from the FMEA), quantity of items in the FOS Real-Time systems, criticality classification for each item, and justification for the item retention.

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System _____ Date_____

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Element/Function_____ Approved By_____

Mission Phase_____

LRU Part No.	Reference Designator	LRU Nomenclature	FMEA ID	Qty	Criticality Level	Justification For Retention

Figure 6-1. Sample Critical Items List (CIL)

6.2 Critical Items List (CIL) Criteria

The FOS CIL comprises items meeting the following criteria as defined in accordance with paragraph 5.3.4 of the PAR:

- Potential catastrophic failures or failures with criticality classification of 1 or 2 that cannot be eliminated from the FOS Critical Real-Time functions.
- Potential critical failures or failures with criticality classification of 3 that cannot be eliminated from the FOS Critical Real-Time functions.

6.3 Critical Items Mitigation Plan

Since there are no criticality classifications 1, 2, or 3 identified at this time, a mitigation plan does not exist. As the FOS design evolves and if there are any critical items identified in future analyses, a mitigation plan will be provided with future updated reports.

6.4 Justification For Retention of Critical Items

Since there are no criticality classifications 1, 2, or 3 identified at this time, a justification for retention of Critical Items does not exist. As the FOS design evolves and if there are any critical items identified in future analyses, a justification for retention of Critical Items will be provided with future updated reports.

Appendix A. FMEA Detailed Worksheets

System EOS
Segment FOS
Element/Function Real-Time Server
Mission Phase Real-Time

Date 12/05/95
Prepared By Bang Nguyen
Approved By H. Brackett

ID Number	Identification of Item	a. Failure Mode b. Failure Cause	Failure Effects a. Local or Subsystem b. Next Higher Level - System c. End Effect - Mission	Criticality Classification	Remarks a. Failure Detection Method b. Compensating Features/Action c. Other
01	R/T Server CPU	a) Premature Operation b) Defective ICs	a) Data Corruption. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
02		a) Failure to operate at prescribed time b) Defective ICs	a) No response. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
03		a) Failure to cease operations when required b) Defective ICs	a) Data Corruption b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
04		a) Failure during operation b) Defective ICs	a) No response or Data Corruption b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
05	32MB Memory	a) Premature Operation b) Defective memory device.	a) Data Corruption. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
06		a) Failure to operate at prescribed time b) Defective memory device.	a) Data lost or no data. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
07		a) Failure to cease operations when required b) Defective memory device.	a) Stuck in read or write state. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
08		a) Failure during operation b) Defective memory device.	a) Data Corruption. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
09	4MM DAT Drive	a) Premature Operation b) Defective controller.	a) No impact. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.

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ID Number	Identification of Item	a. Failure Mode b. Failure Cause	Failure Effects a. Local or Subsystem b. Next Higher Level - System c. End Effect - Mission	Criticality Classification	Remarks a. Failure Detection Method b. Compensating Features/Action c. Other
10		a) Failure to operate at prescribed time b) Defective controller, read/write head or drive motor.	a) Unable to upgrade/install software or perform local backups. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
11		a) Failure to cease operations when required b) Defective controller.	a) Unable to upgrade/install software or perform local backups. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
12		a) Failure during operation b) Defective controller, read/write head or drive motor	a) Unable to upgrade/install software or perform local backups b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
13	2GB Hard Drive	a) Premature Operation b) Defective controller	a) No impact. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
14		a) Failure to operate at prescribed time b) Defective controller, read/write head or drive motor.	a) Unable to access the operating system, swap space, or application software. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
15		a) Failure to cease operations when required b) Defective controller	a) Unable to access the operating system, swap space, or application software. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
16		a) Failure during operation b) Defective controller, read/write head or drive motor	a) Unable to access the operating system, swap space, or application software. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
17	CD ROM	a) Premature Operation b) Defective controller.	a) No impact. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.

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ID Number	Identification of Item	a. Failure Mode b. Failure Cause	Failure Effects a. Local or Subsystem b. Next Higher Level - System c. End Effect - Mission	Criticality Classification	Remarks a. Failure Detection Method b. Compensating Features/Action c. Other
18		a) Failure to operate at prescribed time b) Defective controller, read head or drive motor.	a) Unable to upgrade/install software. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
19		a) Failure to cease operations when required b) Defective controller.	a) Unable to upgrade/install software. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
20		a) Failure during operation b) Defective controller, read head or drive motor.	a) Unable to upgrade/install software. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
21	Monitor	a) Failure to operate at prescribed time b) Defective video tube driver, power supply or tube.	a) No data displayed. b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
22		a) Failure to cease operations when required b) Defective on/off switch.	a) No impact. b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
23		a) Failure during operation b) Defective video tube driver, power supply or tube.	a) No data displayed. b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
24	Keyboard	a) Premature Operation b) Damaged keypad.	a) Incorrect data entry. b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
25		a) Failure to operate at prescribed time b) Damaged keypad	a) No data entry b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
26		a) Failure to cease operations when required b) Stuck key.	a) Incorrect data entry. b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
27		a) Failure during operation b) Damaged keypad	a) No data entry. b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.

System EOS
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ID Number	Identification of Item	a. Failure Mode b. Failure Cause	Failure Effects a. Local or Subsystem b. Next Higher Level - System c. End Effect - Mission	Criticality Classification	Remarks a. Failure Detection Method b. Compensating Features/Action c. Other
28	Power Supply	a) Failure to operate at prescribed time b) Defective voltage converter/regulator, transformer, fuse, etc.	a) No operation of server. b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
29		a) Failure to cease operations when required b) Defective on/off switch.	a) No impact b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
30		a) Failure during operation b) Defective voltage converter/regulator, transformer, fuse, etc.	a) No operation of server.. b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
31	FDDI Controller	a) Premature Operation b) Defective IC.	a) Receive/send unwanted data from/to network. b) None. Switch to standby controller. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
32		a) Failure to operate at prescribed time b) Defective IC.	a) No communication to network b) None. Switch to standby controller. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
33		a) Failure to cease operations when required b) Defective IC.	a) Receive/send unwanted data from/to network. b) None. Switch to standby controller. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
34		a) Failure during operation b) Defective IC.	a) No communication to network. b) None. Switch to standby controller. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Real-Time Servers required to be operational for release A/B.
35	FDDI Port	a) Failure to operate at prescribed time b) Open connection	a) No communication to network. b) None. Switch to standby port. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Ports required to communicate with the network.
36		a) Failure to cease operations when required b) Short to active data line.	a) Receive/send unwanted data to network. b) None. Switch to standby port. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Ports required to communicate with the network.
37		a) Failure during operation b) Open or shorted data line.	a) No communication to network. b) None. Switch to standby port. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Ports required to communicate with the network.

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Prepared By Bang Nguyen
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ID Number	Identification of Item	a. Failure Mode b. Failure Cause	Failure Effects a. Local or Subsystem b. Next Higher Level - System c. End Effect - Mission	Criticality Classification	Remarks a. Failure Detection Method b. Compensating Features/Action c. Other
01	Data Server CPU	a) Premature Operation b) Defective ICs	a) Data Corruption. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
02		a) Failure to operate at prescribed time b) Defective ICs	a) No response. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
03		a) Failure to cease operations when required b) Defective ICs	a) Data Corruption b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
04		a) Failure during operation b) Defective ICs	a) No response or Data Corruption b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
05	32MB Memory	a) Premature Operation b) Defective memory device.	a) Data Corruption. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
06		a) Failure to operate at prescribed time b) Defective memory device.	a) Data lost or no data. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
07		a) Failure to cease operations when required b) Defective memory device.	a) Stuck in read or write state. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
08		a) Failure during operation b) Defective memory device.	a) Data Corruption. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
09	4MM DAT Drive	a) Premature Operation b) Defective controller.	a) No impact. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
10		a) Failure to operate at prescribed time b) Defective controller, read/write head or drive motor.	a) Unable to upgrade/install software or perform local backups. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.

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ID Number	Identification of Item	a. Failure Mode b. Failure Cause	Failure Effects a. Local or Subsystem b. Next Higher Level - System c. End Effect - Mission	Criticality Classification	Remarks a. Failure Detection Method b. Compensating Features/Action c. Other
11		a) Failure to cease operations when required b) Defective controller.	a) Unable to upgrade/install software or perform local backups. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
12		a) Failure during operation b) Defective controller, read/write head or drive motor	a) Unable to upgrade/install software or perform local backups b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
13	2GB Hard Drive	a) Premature Operation b) Defective controller	a) No impact. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
14		a) Failure to operate at prescribed time b) Defective controller, read/write head or drive motor.	a) Unable to access the operating system, swap space, or application software. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
15		a) Failure to cease operations when required b) Defective controller	a) Unable to access the operating system, swap space, or application software. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
16		a) Failure during operation b) Defective controller, read/write head or drive motor	a) Unable to access the operating system, swap space, or application software. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
17	CD ROM	a) Premature Operation b) Defective controller.	a) No impact. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
18		a) Failure to operate at prescribed time b) Defective controller, read head or drive motor.	a) Unable to upgrade/install software. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.

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ID Number	Identification of Item	a. Failure Mode b. Failure Cause	Failure Effects a. Local or Subsystem b. Next Higher Level - System c. End Effect - Mission	Criticality Classification	Remarks a. Failure Detection Method b. Compensating Features/Action c. Other
19		a) Failure to cease operations when required b) Defective controller.	a) Unable to upgrade/install software. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
20		a) Failure during operation b) Defective controller, read head or drive motor.	a) Unable to upgrade/install software. b) None. Switch to standby server. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
21	Monitor	a) Failure to operate at prescribed time b) Defective video tube driver, power supply or tube.	a) No data displayed. b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
22		a) Failure to cease operations when required b) Defective on/off switch.	a) No impact. b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
23		a) Failure during operation b) Defective video tube driver, power supply or tube.	a) No data displayed. b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
24	Keyboard	a) Premature Operation b) Damaged keypad.	a) Incorrect data entry. b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
25		a) Failure to operate at prescribed time b) Damaged keypad	a) No data entry b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
26		a) Failure to cease operations when required b) Stuck key.	a) Incorrect data entry. b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
27		a) Failure during operation b) Damaged keypad	a) No data entry. b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
28	Power Supply	a) Failure to operate at prescribed time b) Defective voltage converter/regulator, transformer, fuse, etc.	a) No operation of server. b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.

System EOS
Segment FOS
Element/Function Data Server
Mission Phase Real-Time

Date 12/05/95
Prepared By Bang Nguyen
Approved By H. Brackett

ID Number	Identification of Item	a. Failure Mode b. Failure Cause	Failure Effects a. Local or Subsystem b. Next Higher Level - System c. End Effect - Mission	Criticality Classification	Remarks a. Failure Detection Method b. Compensating Features/Action c. Other
29		a) Failure to cease operations when required b) Defective on/off switch.	a) No impact b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
30		a) Failure during operation b) Defective voltage converter/regulator, transformer, fuse, etc.	a) No operation of server.. b) None. Switch to standby server. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
31	FDDI Controller	a) Premature Operation b) Defective IC.	a) Receive/send unwanted data from/to network. b) None. Switch to standby controller. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
32		a) Failure to operate at prescribed time b) Defective IC.	a) No communication to network b) None. Switch to standby controller. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
33		a) Failure to cease operations when required b) Defective IC.	a) Receive/send unwanted data from/to network. b) None. Switch to standby controller. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
34		a) Failure during operation b) Defective IC.	a) No communication to network. b) None. Switch to standby controller. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 3 Data Servers required to be operational for release A/B.
35	FDDI Port	a) Failure to operate at prescribed time b) Open connection	a) No communication to network. b) None. Switch to standby port. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 1 of 2 Ports required to communicate with the network..
36		a) Failure to cease operations when required b) Short to active data line.	a) Receive/send unwanted data to network. b) None. Switch to standby port. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 1 of 2 Ports required to communicate with the network..
37		a) Failure during operation b) Open or shorted data line.	a) No communication to network. b) None. Switch to standby port. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 1 of 2 Ports required to communicate with the network..

System EOS
Segment FOS
Element/Function Hub/Bridge
Mission Phase Real-Time

Date 12/05/95
Prepared By Bang Nguyen
Approved By H. Brackett

ID Number	Identification of Item	a. Failure Mode b. Failure Cause	Failure Effects a. Local or Subsystem b. Next Higher Level - System c. End Effect - Mission	Criticality Classification	Remarks a. Failure Detection Method b. Compensating Features/Action c. Other
01	Hub/Bridge	a) Failure to operate at prescribed time b) Defective controller or power supply.	a) No communications b) None. Switch to standby Hub/Bridge. c) None.	4	a) Network software diagnostic. b) Active standby redundancy. c) Only 2 of 4 Hub/Bridge required to be operational.
02		a) Failure to cease operations when required b) Defective controller.	a) Unwanted communications. b) None. Switch to standby Hub/Bridge. c) None.	4	a) Network software diagnostic. b) Active standby redundancy. c) Only 2 of 4 Hub/Bridge required to be operational.
03		a) Failure during operation b) Defective controller or power supply.	a) No communications b) None. Switch to standby Hub/Bridge. c) None.	4	a) Network software diagnostic. b) Active standby redundancy. c) Only 2 of 4 Hub/Bridge required to be operational.

System EOS
Segment FOS
Element/Function Data Storage Unit
Mission Phase Real-Time

Date 12/05/95
Prepared By Bang Nguyen
Approved By H. Brackett

ID Number	Identification of Item	a. Failure Mode b. Failure Cause	Failure Effects a. Local or Subsystem b. Next Higher Level - System c. End Effect - Mission	Criticality Classification	Remarks a. Failure Detection Method b. Compensating Features/Action c. Other
01	Front-end Processor	a) Premature Operation b) Defective CPU.	a) Corrupt stored data b) None. Switch to standby Front-end Processor. c) None.	4	a) Software diagnostics. b) Active standby redundancy. c) Only 1 of 2 Front-end Processors required to be operational.
02		a) Failure to operate at prescribed time b) Defective CPU, Power Supply, Hard Disk, etc.	a) No control of data archiving and retrieval. b) None. Switch to standby Front-end Processor. c) None.	4	a) Software diagnostics. b) Active standby redundancy. c) Only 1 of 2 Front-end Processors required to be operational.
03		a) Failure to cease operations when required b) Defective CPU.	a) Corrupt stored data b) None. Switch to standby Front-end Processor. c) None.	4	a) Software diagnostics. b) Active standby redundancy. c) Only 1 of 2 Front-end Processors required to be operational.
04		a) Failure during operation b) Defective CPU, Power Supply, Hard Disk, etc	a) No control of data archiving and retrieval. b) None. Switch to standby Front-end Processor. c) None.	4	a) Software diagnostics. b) Active standby redundancy. c) Only 1of 2 Front-end Processors required to be operational.
05	Controller Card	a) Premature Operation b) Defective IC.	a) Corrupt stored data b) None. Switch to standby Controller. c) None.	4	a) Software diagnostics. b) Active standby redundancy. c) Only 1 of 2 Controller Cards required to be operational.
06		a) Failure to operate at prescribed time b) Defective IC.	a) No control of data archiving and retrieval. b) None. Switch to standby Controller. c) None.	4	a) Software diagnostics. b) Active standby redundancy. c) Only 1 of 2 Controller Cards required to be operational.
07		a) Failure to cease operations when required b) Defective IC	a) Corrupt stored data b) None. Switch to standby Controller. c) None.	4	a) Software diagnostics. b) Active standby redundancy. c) Only 1 of 2 Controller Cards required to be operational.
08		a) Failure during operation b) Defective IC	a) No control of data archiving and retrieval. b) None. Switch to standby Controller. c) None.	4	a) Software diagnostics. b) Active standby redundancy. c) Only 1 of 2 Controller Cards required to be operational.
09	Power Supply	a) Failure to operate at prescribed time b) Defective voltage converter/regulator, transformer, fuse, etc.	a) No operation of RAID assembly. b) None. Switch to standby Power Supply module. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 1 of 2 Power Supply modules required for operation.
10		a) Failure to cease operations when required b) Defective on/off switch.	a) No impact b) None. Switch to standby Power Supply module. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 1 of 2 Power Supply modules required for operation.

System EOS
Segment FOS
Element/Function Data Storage Unit
Mission Phase Real-Time

Date 12/05/95
Prepared By Bang Nguyen
Approved By H. Brackett

ID Number	Identification of Item	a. Failure Mode b. Failure Cause	Failure Effects a. Local or Subsystem b. Next Higher Level - System c. End Effect - Mission	Criticality Classification	Remarks a. Failure Detection Method b. Compensating Features/Action c. Other
11		a) Failure during operation b) Defective voltage converter/regulator, transformer, fuse, etc.	a) No operation of RAID assembly. b) None. Switch to standby Power Supply module. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 1 of 2 Power Supply modules required for operation.
12	Fan	a) Failure to operate at prescribed time b) Defective motor.	a) No airflow. b) None. Switch to standby fan. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 1 of 2 fans required for operation.
13		a) Failure during operation b) Defective motor	a) No airflow. b) None. Switch to standby fan. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 1 of 2 fans required for operation.
14	FDDI Driver	a) Premature Operation b) Defective IC.	a) Receive/send unwanted data from/to network. b) None. Switch to standby FDDI Driver. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 1 of 2 FDDI Driver required to be operational.
15		a) Failure to operate at prescribed time b) Defective IC.	a) No communication to network b) None. Switch to standby FDDI Driver. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 1 of 2 FDDI Driver required to be operational.
16		a) Failure to cease operations when required b) Defective IC.	a) Receive/send unwanted data from/to network. b) None. Switch to standby FDDI Driver. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 1 of 2 FDDI Driver required to be operational.
17		a) Failure during operation b) Defective IC.	a) No communication to network. b) None. Switch to standby FDDI Driver. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 1 of 2 FDDI Driver required to be operational.
18	FDDI Port	a) Failure to operate at prescribed time b) Open connection	a) No communication to network. b) None. Switch to standby port. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 1 of 2 Ports required to communicate with the network..
19		a) Failure to cease operations when required b) Short to active data line.	a) Receive/send unwanted data to network. b) None. Switch to standby port. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 1 of 2 Ports required to communicate with the network..
20		a) Failure during operation b) Open or shorted data line.	a) No communication to network. b) None. Switch to standby port. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 1 of 2 Ports required to communicate with the network..

System EOS
Segment FOS
Element/Function RAID Storage Unit
Mission Phase Real-Time

Date 12/05/95
Prepared By Bang Nguyen
Approved By H. Brackett

ID Number	Identification of Item	a. Failure Mode b. Failure Cause	Failure Effects a. Local or Subsystem b. Next Higher Level - System c. End Effect - Mission	Criticality Classification	Remarks a. Failure Detection Method b. Compensating Features/Action c. Other
21	2GB Hard Disk RAID	a) Failure to operate at prescribed time b) Defective controller	a) No impact. b) None. Switch to standby disk. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 12 of 16 disks required to be operational.
22		a) Failure to cease operations when required b) Defective controller, read/write head or drive motor.	a) Failure to archive and retrieve data. b) None. Switch to standby disk. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 12 of 16 disks required to be operational.
23		a) Failure during operation b) Defective controller, read/write head or drive motor.	a) Failure to archive and retrieve data. b) None. Switch to standby disk. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 12 of 16 disks required to be operational.

System EOS
Segment FOS
Element/Function User Station
Mission Phase Real-Time

Date 12/05/95
Prepared By Bang Nguyen
Approved By H. Brackett

ID Number	Identification of Item	a. Failure Mode b. Failure Cause	Failure Effects a. Local or Subsystem b. Next Higher Level - System c. End Effect - Mission	Criticality Classification	Remarks a. Failure Detection Method b. Compensating Features/Action c. Other
01	User Station CPU	a) Premature Operation b) Defective ICs	a) Data Corruption. b) None. Switch to standby user workstation. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.
02		a) Failure to operate at prescribed time b) Defective ICs	a) No response. b) None. Switch to standby user workstation. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.
03		a) Failure to cease operations when required b) Defective ICs	a) Data Corruption b) None. Switch to standby user workstation. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.
04		a) Failure during operation b) Defective ICs	a) No response or Data Corruption b) None. Switch to standby user workstation. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.
05	4.3GB Hard Drive	a) Premature Operation b) Defective controller	a) No impact. b) None. Switch to standby user workstation. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.
06		a) Failure to operate at prescribed time b) Defective controller, read/write head or drive motor.	a) Unable to access the operating system, swap space, or application software. b) None. Switch to standby user workstation. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.
07		a) Failure to cease operations when required b) Defective controller	a) Unable to access the operating system, swap space, or application software. b) None. Switch to standby user workstation. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.
08		a) Failure during operation b) Defective controller, read/write head or drive motor	a) Unable to access the operating system, swap space, or application software. b) None. Switch to standby user workstation. c) None.	4	a) Software diagnostic. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.
09	Monitor	a) Failure to operate at prescribed time b) Defective video tube driver, power supply or tube.	a) No data displayed. b) None. Switch to standby user workstation. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.

System EOS
Segment FOS
Element/Function User Workstation
Mission Phase Real-Time

Date 12/05/95
Prepared By Bang Nguyen
Approved By H. Brackett

ID Number	Identification of Item	a. Failure Mode b. Failure Cause	Failure Effects a. Local or Subsystem b. Next Higher Level - System c. End Effect - Mission	Criticality Classification	Remarks a. Failure Detection Method b. Compensating Features/Action c. Other
10		a) Failure to cease operations when required b) Defective on/off switch.	a) No impact. b) None. Switch to standby user workstation. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.
11		a) Failure during operation b) Defective video tube driver, power supply or tube.	a) No data displayed. b) None. Switch to standby user workstation. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.
12	Keyboard	a) Premature Operation b) Damaged keypad.	a) Incorrect data entry. b) None. Switch to standby user workstation. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.
13		a) Failure to operate at prescribed time b) Damaged keypad	a) No data entry b) None. Switch to standby user workstation. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.
14		a) Failure to cease operations when required b) Stuck key.	a) Incorrect data entry. b) None. Switch to standby user workstation. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.
15		a) Failure during operation b) Damaged keypad	a) No data entry. b) None. Switch to standby user workstation. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.
16	Power Supply	a) Failure to operate at prescribed time b) Defective voltage converter/regulator, transformer, fuse, etc.	a) No operation of user workstation. b) None. Switch to standby user workstation. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.
17		a) Failure to cease operations when required b) Defective on/off switch.	a) No impact b) None. Switch to standby user workstation. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.
18		a) Failure during operation b) Defective voltage converter/regulator, transformer, fuse, etc.	a) No operation of user workstation.. b) None. Switch to standby user workstation. c) None.	4	a) Visual indication. b) Active standby redundancy. c) Only 2 of 36 User workstations required to be operational for release A/B.

System EOS
Segment FOS
Element/Function Time Systems
Mission Phase Real-Time

Date 12/05/95
Prepared By Bang Nguyen
Approved By H. Brackett

ID Number	Identification of Item	a. Failure Mode b. Failure Cause	Failure Effects a. Local or Subsystem b. Next Higher Level System c. End Effect - Mission	Criticality Classification	Remarks a. Failure Detection Method b. Compensating Features/Action c. Other
01	Time Systems	a) Failure to operate at prescribed time b) Defective GPS Satellite Receiver, Time Code Decoder or Processor.	a) No time input signal. b) None. Switch to standby timing system. c) None.	4	a) Software diagnostic. b) Standby redundancy. c) Only 1 of 2 Timing Systems required for operation.
02		a) Failure during operation b) Defective GPS Satellite Receiver, Time Code Decoder or Processor.	a) No time input signal. b) None. Switch to standby timing system. c) None.	4	a) Software diagnostic. b) Standby redundancy. c) Only 1 of 2 Timing Systems required for operation.

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Abbreviations and Acronyms

AGS	ASTER Ground System
AM	Morning (ante meridian) -- see EOS AM
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer (formerly ITIR)
ATC	Absolute Time Command
BAP	Baseline Activity Profile
CAC	Command Activity Controller
CCSDS	Consultative Committee for Space Data Systems
CDR	Critical Design Review
CERES	Clouds and Earth's Radiant Energy System
CI	Configuration item
CIL	Critical Items List
CLCW	Command Link Control Words
CMS	Command Management System
COTS	Commercial Off-The-Shelf
CSCI	Computer software configuration item
CSMS	Communications and System Management Segment
CSS	Communications Subsystem (CSMS)
DAR	Data Acquisition Request
DAS	Detailed Activity Schedule
DAT	Digital Tape Drive
DB	Database
DBMS	Database Management System
DID	Data item description; data ingest/distribution
DSN	Deep Space Network
DSS	Decision Support System
ECOM	EOS Communications
ECS	EOSDIS Core System
EDOS	EOS Data and Operations System

EOC	EOS Operations Center
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
ESN	EOS Science Network
FDF	Flight Dynamics Facility
FMEA	Failure Modes and Effects Analyses
FOS	Flight Operations Segment (ECS)
FOT	Flight Operations Team
GFE	Government Furnished Equipment
ICC	Instrument Control Center
IDR	Incremental Design Review
IP	International Partners
IRD	Interface requirements document
IST	Instrument Support Toolkit
IWG	Investigators Working Group
JPL	Jet Propulsion Laboratory
LAN	Local Area Network
LaRC	Langley Research Center
LRU	Line Replacement Unit
LSM	Local System Manager
LTIP	Long Term Instrument Plan
LTSP	Long Term Science Plan
MISR	Multi-Angle Imaging SpectroRadiometer
MO&DSD	Mission Operations and Data Systems Directorate (GSFC Code 500)
MODIS	Moderate Resolution Imaging Spectrometer
MOPITT	Measurements of Pollution in the Troposphere
MSS	CSMS Management Subsystem
MTPE	Mission to Planet Earth
Nascom	NASA Communications Network
NASDA	National Space Development Agency (Japan)
NCC	Network Control Center

NOAA	National Oceanic and Atmospheric Administration
OMT	Object Model Technique
OOD	Object Oriented Design
P&S	Planning and Scheduling
PDB	Project Data Base
PI	Principal Investigator
PI/TL	Principal Investigator/Team Leader
PSAT	Predicted Site Acquisition Table
RMA	Reliability, Maintainability, Availability
SCF	Science Computing Facility
SDVF	Software Development and Validation Facility
SMC	Service Management Center
SN	Space Network
SSIM	Spacecraft Simulator
SSR	Solid State Recorder
STOL	System Test and Operations Language
TD	Target Day
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TL	Team Leader
TOO	Target of Opportunity
TW	Target Week
UAV	User Antenna View
UI	User Interface
WAN	Wide Area Network
WOTS	Wallops Orbital Tracking Station